CLAIMS

1. A real image mode variable magnification finder optical system comprising:

a variable magnification objective optical system having a positive optical power;

an ocular optical system having a positive optical power; and

a plurality of reflecting surfaces for erecting an image of an object to be observed;

said objective optical system including a plurality of movable lens units each of which has an aspherical surface, and at least one reflecting surface which is a rotationally asymmetric surface and has an optical power;

said finder optical system satisfying the following condition:

$$0.02 < d(fw/ft^2) < 0.4 \quad (1)$$

where d is a distance from a first surface of said objective optical system to one of said reflecting surfaces positioned nearest to an object measured along an axial chief ray at a wide angle end, fw is a focal length of said objective optical system at a wide angle end, and ft is a focal length of said objective optical system at a telephoto end.

2. A real image mode variable magnification finder optical system according to claim 1, further satisfying the following condition:

$$2.5 \leqq ft/fw \leqq 10 \quad (2)$$

3. A real image mode variable magnification finder optical system according to claim 1, wherein said objective optical system includes at least three lens units.

4. A real image mode variable magnification finder optical system according to claim 1, wherein said movable lens units include no reflecting surfaces.

5. A real image mode variable magnification finder optical system according to claim 1, wherein said objective optical system comprises a negative subsystem including at least one positive lens unit and two negative lens units.

6. A real image mode variable magnification finder optical system according to claim 5, wherein said negative subsystem is disposed at an object side of said plurality of reflecting surfaces.

7. A real image mode variable magnification finder optical system according to claim 5, wherein said negative subsystem includes no lens element having an reflecting surface.

8. A real image mode variable magnification finder optical system according to claim 5, wherein said negative subsystem satisfies the following condition:

$$0.02 < fw/fneg < 0.9 \qquad (3)$$

where fneg is a focal length of said negative subsystem.

9. A real image mode variable magnification finder optical system according to claim 5, wherein said negative subsystem satisfies the following condition:

$$0.2 < |fN/fP| < 1.7 \qquad (4)$$

where fP is a focal length of a positive lens unit which has a strongest positive optical power in said negative subsystem and fN is a focal length of a negative lens unit which has a strongest negative optical power in said negative subsystem.

10. A real image mode variable magnification finder optical system according to claim 1, wherein said objective optical system comprises a positive subsystem including at least two positive lens units and one negative lens unit.

11. A real image mode variable magnification finder optical system according to claim 10, wherein said positive subsystem is disposed at an object side of said plurality of reflecting surfaces.

12. A real image mode variable magnification finder optical system according to claim 10, wherein said positive subsystem includes no lens element having an reflecting surface.

13. A real image mode variable magnification finder optical system according to claim 10, wherein said positive subsystem satisfies the following condition:

$$0.7 < fw/fpos < 3.0 \qquad (5)$$

where fpos is a focal length of said positive subsystem.

14. A real image mode variable magnification finder optical system according to claim 10, wherein said positive subsystem satisfies the following condition:

$$0.8 < |fP/fN| < 2.5 \qquad (6)$$

where fP is a focal length of a positive lens unit which has a strongest positive optical power in said positive subsystem and fN is a focal length of a negative lens unit which has a strongest negative optical power in said positive subsystem.

15. A real image mode variable magnification finder optical system according to claim 10, wherein at least one of lens units included in said positive subsystem is fixed on an optical axis during zooming operation.

16. A real image mode variable magnification finder optical system according to claim 1, wherein said objective optical system comprises, in order from an object side, a negative first lens unit, a positive second lens unit and a positive third lens unit, and at least said first lens unit is fixed on an optical axis during zooming operation.

17. A real image mode variable magnification finder optical system according to claim 1, wherein said objective optical system comprises, in order from an object side, a positive first lens unit, a negative second lens unit and a negative third lens unit.

18. A real image mode variable magnification finder optical system according to claim 1, wherein said objective optical system comprises, in order from an object side, a negative first lens unit, a positive second lens unit and a negative third lens unit.

19. A real image mode variable magnification finder optical system according to claim 18, wherein said negative first lens unit is fixed on an optical axis during zoom operation.

20. A real image mode variable magnification finder optical system according to claim 18, wherein a composite focal length of said first, second and third lens units is negative.

21. A real image mode variable magnification finder optical system according to claim 1, wherein at least one of said reflecting surfaces disposed on an object side of an intermediate image formed by said objective optical system has a positive optical power and satisfies the following condition:

$$0.015 < |\, 2n \cdot \tan\theta \cdot Ih/r \,| < 1.5 \qquad (7)$$

where r is a radius of curvature of said at least one reflecting surface at a point that an axial chief ray intersects said reflecting surface, n is a refractive index of a medium arranged on both an entrance and a reflection side of said reflecting surface at a wavelength of the d-line, θ is a reflection angle on said reflecting surface, and Ih is a length of a diagonal line of a field mask arranged on or in the vicinity of said intermediate image.

22. A real image mode variable magnification finder optical system according to claim 1, wherein at least one of said reflecting surfaces disposed on an object side of an intermediate image formed by said objective optical system has a negative optical power and satisfies the following condition:

$$0.015 < |\, 2n \cdot \tan\theta \cdot Ih/r \,| < 1.5 \qquad (8)$$

where r is a radius of curvature of said at least one reflecting surface at a point that an axial chief ray intersects said reflecting surface, n is a refractive index of a medium arranged on both an entrance and a reflection side of said reflecting surface at a wavelength of the d-line, θ is a reflection angle on said reflecting surface, and Ih is a length of a diagonal line of a field mask arranged on or in the vicinity of said intermediate image.

23. A real image mode variable magnification finder optical system according to claim 1, wherein at least one positive reflecting surface and at least one negative reflecting surface which are disposed on an object side of an intermediate image formed by said objective optical system are included in said plurality of reflecting surfaces.

24. A real image mode variable magnification finder optical system according to claim 23, wherein said plurality of reflecting surfaces include a positive reflecting surface and a negative reflecting surface both satisfying the following condition:

$$0.015 < |\, 2n \cdot \tan\theta \cdot Ih/r \,| < 1.5 \qquad (9)$$

where r is a radius of curvature of said positive and negative reflecting surfaces at a point that an axial chief ray intersects said reflecting surfaces, n is a refractive index of a medium arranged on both an entrance and a reflection side of said reflecting surfaces at a wavelength of the d-line, θ is a reflection angle on said reflecting surfaces, and Ih is a length of a diagonal line of a field mask arranged on or in the vicinity of said intermediate image.

25. A real image mode variable magnification finder optical system according to claim 1, wherein only two reflecting surfaces are arranged on an object side of an intermediate image formed by said objective optical system.

26. A real image mode variable magnification finder optical system according to claim 1, wherein only three reflecting surfaces are arranged on an object side of an intermediate image formed by said objective optical system.

27. A real image mode variable magnification finder optical system according to claim 1, wherein at least one of said plurality of reflecting surfaces comprises a totally reflecting surface.

28. A real image mode variable magnification finder optical system according to claim 1, wherein at least one of said plurality of reflecting surfaces satisfies the following condition:

$$5^\circ < \theta < 60^\circ \quad (10)$$

where θ is a reflection angle of an axial chief ray.

29. A real image mode variable magnification finder optical system according to claim 1, wherein a reflecting surface disposed on an object side of an intermediate image formed by said objective optical system is formed on a prism whose entrance surface is formed as a rotationally asymmetric refracting surface.

30. A real image mode variable magnification finder optical system according to claim 1, wherein a reflecting surface disposed on an object side of an intermediate image formed by said objective optical system is formed on a prism whose exit surface is formed as a rotationally asymmetric refracting surface.

31. A real image mode variable magnification finder optical system according to claim 1, wherein a reflecting surface disposed on an object side of an intermediate image formed by said objective optical system is fixed on an optical axis during zooming operation.

32. A real image mode variable magnification finder optical system according to claim 1, wherein said plurality of reflecting surfaces includes a roof shaped reflecting surface and said plurality of reflecting surfaces reflect a light ray six times in total.

33. A real image mode variable magnification finder optical system according to claim 1, wherein said plurality of reflecting surfaces form a Porro-prism which reflect a light ray four times in total.

34. A real image mode variable magnification finder optical according to claim 1, wherein an exit pupil of said objective optical system is rotationally symmetrically corrected.

35. A real image mode variable magnification finder optical according to claim 1, wherein said finder optical system is so configured that an axial chief rays entering said objective optical system and an axial chief ray exiting said ocular optical system are parallel or substantially parallel with each other.

36. A real image mode variable magnification finder optical system according to claim 35, wherein an angle ϕ between the axial chief rays entering said objective optical system and the axial chief ray exiting said ocular optical system satisfies the following condition:

$$0^\circ \leqq \phi < 20^\circ \quad (11)$$

37. A real image mode variable magnification finder optical system according to claim 1, wherein an angle α between an axial chief ray entering said objective optical system and an

axial chief ray entering an intermediate image formed by said objective optical system satisfies the following condition:

$$15^\circ < \alpha < 75^\circ \quad \text{or} \quad 105^\circ < \alpha \leqq 180^\circ \qquad (12)$$

38. A real image mode variable magnification finder optical system according to claim 1, wherein said objective optical system of said finder optical system forms only one intermediate image.

39. A real image mode variable magnification finder optical system according to claim 1, wherein at least two rotationally asymmetric reflecting surface are disposed on an object side of an intermediate image formed by said objective optical system for erecting image.

40. A picture taking apparatus comprising:

a picture taking optical system; and

a variable magnification finder optical system provided aside from said picture taking optical system and so arranged that an axial chief ray entering said picture taking optical system and an axial chief ray entering said finder optical system are parallel or substantially parallel with each other;

wherein said variable magnification finder optical system is said finder optical system according to claim 1.

41. A real image mode variable magnification finder optical system comprising:

a variable magnification objective optical system having a positive optical power;

an ocular optical system having a positive optical power; and

a plurality of reflecting surfaces for erecting an image of an object to be observed;

said objective optical system including a plurality of movable lens units each of which has an aspherical surface, and at least one reflecting surface which is a rotationally asymmetric surface and has an optical power;

said finder optical system satisfying the following conditions:

$$0.02 < d(fw/ft^2) < 0.7 \quad (1')$$

$$3.5 \leqq ft/fw \leqq 10 \quad (2')$$

where d is a distance from a first surface of said objective optical system to one of said reflecting surface positioned nearest to an object measured along an axial chief ray at a wide angle end, fw is a focal length of said objective optical system at a wide angle end, and ft is a focal length of said objective optical system at a telephoto end.

42. A real image mode variable magnification finder optical system comprising:

a variable magnification objective optical system having a positive optical power;

an ocular optical system having a positive optical power; and

a plurality of reflecting surfaces for erecting an image of an object to be observed;

said objective optical system comprising, in order from an object side, a negative front subsystem including a plurality of movable lens units and a rear subsystem including at least one reflecting surface which is a rotationally asymmetric surface and has a positive optical power.

43. A real image mode variable magnification finder optical system according to claim 42, satisfying the following condition:

$$0.02 < d(fw/ft^2) < 0.7 \quad (1')$$

where d is a distance from a first surface of said objective optical system to one of said reflecting surfaces positioned nearest to an object to be observed measured along an axial chief ray at a wide angle end, fw is a focal length of said objective optical system at a wide angle end, and ft is a focal length of said objective optical system at a telephoto end.

44. A real image mode variable magnification finder optical system according to claim 42, satisfying the following condition:

$$2.5 \leqq ft/fw \leqq 10.0 \qquad (2)$$

where fw is a focal length of said objective optical system at a wide angle end, and ft is a focal length of said objective optical system at a telephoto end.

45. A real image mode variable magnification finder optical system comprising:

a variable magnification objective optical system having a positive optical power;

an ocular optical system having a positive optical power; and

a plurality of reflecting surfaces for erecting an image of an object to be observed;

said objective optical system comprising, in order from an object side, a positive front subsystem including at least one fixed lens unit and a plurality of movable lens units, and a rear subsystem including at least one reflecting surface which is a rotationally asymmetric surface and has a negative optical power, and

each of said lens units included in the front subsystem having an aspherical surface.

46. A real image mode variable magnification finder optical system comprising:

a variable magnification objective optical system having a positive optical power;

an ocular optical system having a positive optical power; and

a plurality of reflecting surfaces for erecting an image of an object to be observed;

said objective optical system comprising, in order from an object side, a plurality of movable lens units and a prism which has an entrance surface and a first reflecting surface successive to said entrance surface, said entrance surface and said first reflecting surface having a positive optical power, respectively, and said first reflecting surface being a rotationally asymmetric surface.

47. A real image mode variable magnification finder optical comprising:

a variable magnification objective optical system having a positive optical power;

an ocular optical system having a positive optical power; and

a plurality of reflecting surfaces for erecting an image of an object to be observed;

said objective optical system comprising, in order from an object side, a plurality of movable lens units and a prism which has an entrance surface and a first reflecting surface successive to said entrance surface, said entrance surface and said first reflecting surface having a negative optical power, respectively, and said first reflecting surface being a rotationally asymmetric surface.

48. A real image mode variable magnification finder optical system comprising:

a variable magnification objective optical system having a positive optical power;

an ocular optical system having a positive optical power; and

a plurality of reflecting surfaces for erecting an image of an object to be observed;

said objective optical system comprising a plurality of movable lens units, two reflecting surfaces each having a negative optical power, and a reflecting surface having a positive optical power in this order from an object side; and

at least one of said three reflecting surfaces being a rotationally asymmetric surface.

49. A real image mode variable magnification finder optical system comprising:

a variable magnification objective optical system having a positive optical power;

an ocular optical system having a positive optical power; and

a plurality of reflecting surfaces for erecting an image of an object to be observed;

said objective optical system comprising a plurality of movable lens units, two reflecting surfaces each having a positive optical power, and a reflecting surface having a negative optical power in this order from an object side; and

at least one of said three reflecting surfaces being a rotationally asymmetric surface.

50. A real image mode variable magnification finder optical system comprising:

a variable magnification objective optical system having a positive optical power;

an ocular optical system having a positive optical power; and

a plurality of reflecting surfaces for erecting an image of an object to be observed;

said objective optical system comprising at least three lens units and at least three reflecting surfaces, and at least one of said three reflecting surfaces being a rotationally asymmetric surface.

51. A real image mode variable magnification finder optical system according to claim 50, wherein at least one of said lens units included in said objective optical system is a fixed lens unit.

52. A real image mode variable magnification finder optical system comprising:

a variable magnification objective optical system having a positive optical power;

an ocular optical system having a positive optical power; and

a plurality of reflecting surfaces for erecting an image of an object to be observed;

said objective optical system comprising at least three lens units aligned on a common optical axis, two reflecting surfaces at least one of which is a rotationally asymmetric surface, and a prism having an entrance surface and an exit surface at least one of which is a rotationally asymmetric surface.

53. A real image mode variable magnification finder optical system comprising:

an objective optical system having a positive optical power, an ocular optical system having a positive optical power, and a plurality of reflecting surfaces for erecting an image of an object to be observed;

said objective optical system including a plurality of movable lens units and a prism having a reflecting surface for erecting an image, said prism having, in order from an object toward the light traveling direction, an entrance surface, a first reflecting surface, a second reflecting surface, a third reflecting surface, and an exit surface;

wherein when a plane including three intersecting points of each of said entrance surface, said first reflecting surface, said second reflecting surface and an axial chief ray is defined as a reference plane, said first and second reflecting surfaces are so configured that said axial chief ray or projection thereof onto said reference plane is deflected in a same angular directions relative to a traveling direction of said chief ray on said first and second reflecting surfaces, relative to a traveling direction of said axial chief ray; and

wherein said third reflecting surface is so configured that said axial chief ray or projection thereof onto said reference plane is deflected in an opposite angular direction to that by said first and second reflecting surfaces, relative to a traveling direction of said axial chief ray.

54. A real image mode variable magnification finder optical according to claim 53, further comprising a field mask for defining a visual field just at an exit side of said exit surface of said prism.

55. An real image mode variable magnification finder according to claim 53, wherein an angle between an entering direction of an axial chief ray to said first reflecting surface and an entering direction of an axial chief ray to said third reflecting surface is an obtuse angle, and an angle between an entering direction of an axial chief ray to said first reflecting surface and an entering direction of an axial chief ray to said exit surface is an acute angle.

56. A real image mode variable magnification finder optical system according to claim 55, wherein said second reflecting surface and said exit surface are formed on a same surface of said prism.

57. A real image mode variable magnification finder optical system according to claim 53, wherein said entrance surface is a curved surface.

58. A real image mode variable magnification finder optical system according to claim 53, wherein said plurality of reflecting surfaces includes a roof shaped reflecting surface for erecting an image.

59. An real image mode variable magnification finder according to claim 58, wherein said roof shaped reflecting surface is included in said ocular optical system disposed on an eye side of an intermediate image formed by said objective optical system.

60. An real image mode variable magnification finder according to claim 53, wherein said ocular optical system includes a second prism having, in order from an object toward the light traveling direction, an entrance surface, a first reflecting surface, a second reflecting surface, and an exit surface;

wherein when a plane including three intersecting points of each of said entrance surface, said first reflecting surface, said second reflecting surface and an axial chief ray is defined as a reference plane, said first and second reflecting surfaces are so configured that an axial chief ray or projection thereof onto said reference plane is deflected in one angular direction relative to a traveling direction of said axial chief ray on said first reflecting surface, and an axial chief ray or projection thereof onto said reference plane is deflected in opposite angular direction to that by said first reflecting surface, relative to traveling direction of said axial chief ray on said second reflecting surface,

wherein said second reflecting surface is formed as a roof shaped reflecting surface, and

wherein said first reflecting surface and said exit surface are formed on a same surface of said prism.